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Vegetation of the "Altipiani di Colfiorito" wetlands (central Apennines, Italy)

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Abstract

The "Altipiani di Colfiorito" catchment basin in central Italy features a wetland system of great interest for conservation, composed of seven plains. Considering that most of the relevés conducted in the past refer to one plain and date back to the 1960s, the research aim was to widen and update the vegetation knowledge in the whole wetland system. Two hundred and thirty-nine phytosociological relevés were carried out using the Braun-Blanquet method. On the basis of cluster analysis of the species data set and phytosociological interpretation, 39 vegetation types were classified, most of which of high conservation interest in central Italy, referred to the *Potamogetonetea* (6 communities), *Bidentetea* (2), *Phragmito-Magnocaricetea* (21), *Molinio-Arrhenatheretea* (9), and *Epilobietea angustifolii* (1) classes. The new subassociation *Phalaridetum arundinaceae alopecuretosum bulbosi* is also described. Twenty-two communities found in the past decades by other authors were confirmed, while 17 were new records for the study area. Ten communities were attributed to four habitats of community interest according to the 92/43/EEC Directive, coded as 3150, 3260, 3270, and 6510. Twenty-four communities were not confirmed (eight of *Charetea*, *Lemnetea minoris*, and *Potamogetonetea*, one of *Bidentetea*; seven of *Phragmito-Magnocaricetea*; three of *Scheuchzerio-Caricetea fuscae*, four of *Molinio-Arrhenatheretea* and one of *Isoëto-Nanojuncetea*). Three habitats of community interest (3140, 3170*, and 7230) were not confirmed.

Keywords

central Italy, habitats of community interest, humid meadows, lacustrine habitat, marshland, nature conservation

Introduction

Wetlands represent important ecosystems at the European level (Landucci et al. 2015). The central Apennine (Italy) wetland systems of tectonic-karstic basins are important hotspots of plant and animal biodiversity (Ciaschetti et al. 2020), but management abandonment and such anthropic pressures as drainage, water extraction, tillage, and excavations have greatly reduced their extent and worsened their conservation status (Pedrotti 1965, 1996, 2019; Ballelli et al. 2010; Catorci et al. 2010).

The "Altipiani di Colfiorito" catchment basin hosts one of the most important wetlands of central Italy and is highly worthy of conservation because of its landscape, plant and animal biodiversity, and ecology (Orsomando and Catorci 1998; Renzini 1998; Tardella 2007). This area includes a wetland protected by the Ramsar Convention, an Important Bird Area, three Special Areas of Conservation, and a Special Protection Area of the Natura 2000 network, according to the 92/43/EEC Directive. Since 1995, part of this wetland system has been included in the Parco di Colfiorito, a Regional Park of Umbria.

Several authors (e.g. Pedrotti 1965, 1996, 2019; Ballelli et al. 2001; Brusaferro et al. 2008; Catorci et al. 2010; Lastrucci et al. 2017a, b, 2019a) pointed out the modifications of this wetland in the past decades, which have led to the reduction in extension, worsening of conservation status or local extinction of rare and endangered plant

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communities, some of which deemed habitats of community interest (Biondi et al. 2010). Moreover, this wetland system includes the Habitat "C1.6a Temperate temporary waterbody" that, although is qualified for Least Concern in the European Red List of habitats and, thus, is not deemed threatened at the European level, in Italy has a declining trend in extent and quality (Janssen et al. 2016).

Most of the studies about the vegetation of this district have been conducted at the Palude di Colfiorito, in the central part of the catchment basin, since the 1960s by Pedrotti, who published the vegetation map (Pedrotti 1975) and the related phytosociological relevés (Pedrotti 2019), which date back to the years 1963-1968, along with some new relevés (Pedrotti 2019; Pedrotti and Murrja 2020). Some other relevés at the Palude di Colfiorito have been published by Pedrotti (1979), Buchwald (1992, 1994), and Lastrucci et al. (2017a). A few relevés are available for the other wetlands (Aleffi and Cortini Pedrotti 1995; Pedrotti 2019).

Considering that the plant sociology of plant communities in the whole system of the "Altipiani di Colfiorito" had never been exhaustively analysed and that most of the relevés conducted in the past refer to the only Palude di Colfiorito and date back to the 1960s, the research goal was to classify the plant communities that compose the vegetation of the wet environments, widening and updating the vegetation knowledge of the wetland system.

Methods

Study area

The study area, known as the "Altipiani di Colfiorito", is located between Umbria and Marche in central Italy (Fig. 1) (coordinate range 42° 59.40'–43° 04.50' N, 12° 50.30'–12° 55.80' E), at altitudes ranging from 750 to 810 m a.s.l., and consists of seven plains, named the Palude di Colfiorito, Piano di Colfiorito, Piano di Popola e Cesi, Piano di Annifo, Piano di Arvello, Piano di Colle Croce, and Piano di Ricciano (Appendix I).

In terms of bioclimate, the study area is in the lower supratemperate bioclimatic belt, whose thermotype is lower supratemperate and the ombrotype is lower humid (Pesaresi et al. 2017); the mean annual temperature ranges from 11 to 13 °C and the mean annual precipitation from 1000 to 1100 mm (Orsomando et al. 2000).

The geological substratum is composed of limestones and the plains are covered by lake and marshy deposits, such as gravel, clay, silty clay, and peat (Materazzi and Pieruccini 2001). Soils are deep, hydromorphic, subacid, rich in organic matter, with silty clayey texture and scarce or absent skeleton (Giovagnotti et al. 2003).

The water supply is mainly provided by rainfall, which is maximum in autumn-winter-spring and minimum in summer, while only a small part derives from some torrent waterways and small springs. This rainfall trend determines significant water level fluctuations, namely the increase of the water-covered areas for short periods, followed by their drainage in summer. Swallow holes at the borders of the plains are the only form of natural drainage and are a surface effect of underground karstic phenomena. A hydric system composed of artificial canals and ditches of moderate depth drains water to swallow holes.

The plains are mainly covered by aquatic and marsh vegetation, humid hay meadows, and arable lands, cultivated mainly with wheat, barley, spelt, lentils, and potatoes, alternated with copses of woody hygrophilous vegetation. The areas between the plains and slopes of the surrounding mountains host agricultural land, small mixed woodlands with *Quercus cerris* and *Carpinus betulus* and with *Q. cerris* and *Ostrya carpinifolia*, hay meadows, and dry grasslands (Orsomando and Pambianchi 2002).

Land use history and anthropic pressure

The study area has a long land use history. Artificial underground drainage systems were built about two thousand years ago by the Romans and, more recently (1458-1464) by the Da Varano Dukes. The latter, called "Botte dei Varano", caused the complete drainage of the Piano di Colfiorito that until then had hosted a lake (Mengozzi 1781; Pedrotti 2019). Between 1492 and 1631 numerous attempts were carried out to drain the Palude di Colfiorito, by excavating and progressively enlarging the swallow holes, digging canals and ditches, but they never succeeded in the complete reclamation of the basin (Sensi 1998; Pedrotti 2019). Even in the last century, the Palude di Colfiorito was subjected to numerous attempts of reclamation to widen the extent of croplands (Lippi-Boncambi 1940; Pedrotti and Pettorossi 1968, 1969; Pedrotti 2019).

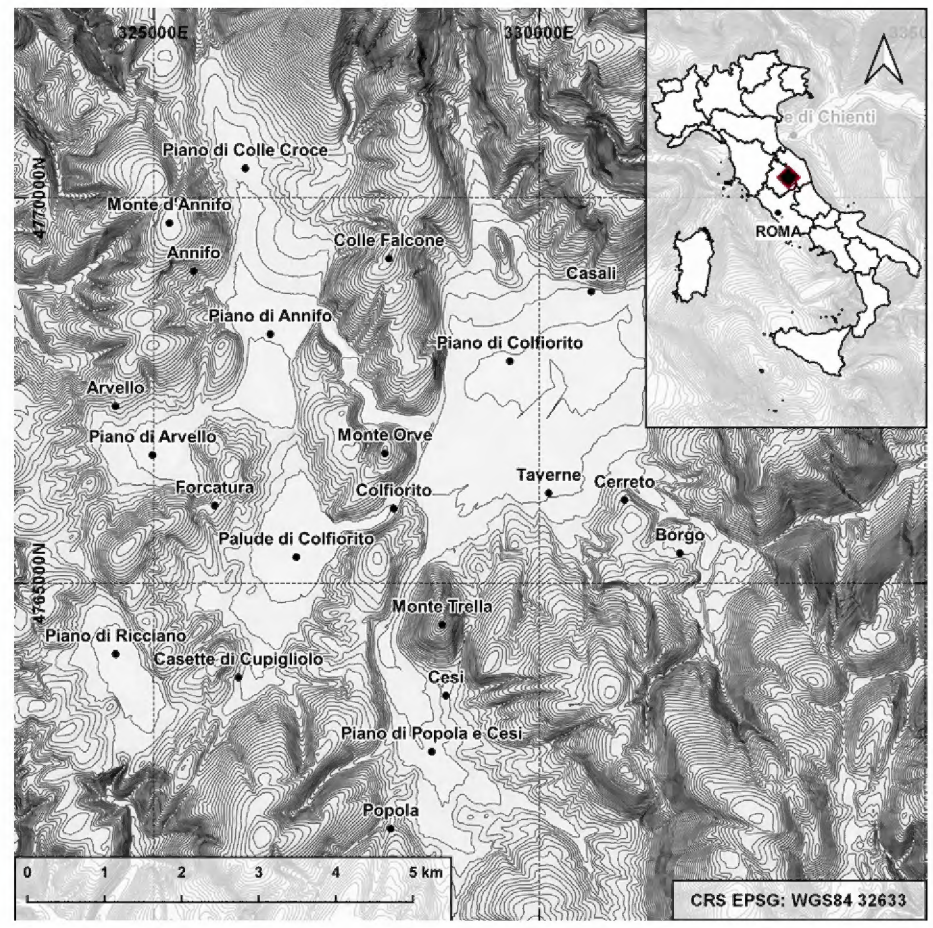

Figure 1. Location of the "Altipiani di Colfiorito" (central Italy).

Photographic documentation of the Palude di Colfiorito shows that in the 1940s-early 1950s, this wetland was almost completely flooded during the rainy part of the year, appearing as a lacustrine area surrounded by a belt of *Phragmites australis* and *Schoenoplectus lacustris*, and was indeed called Lake of Colfiorito (Brusaferro et al. 2008; Catorci et al. 2010; Pedrotti 2019). The reed was contained by flame weeding to foster the presence of anatids for hunting purposes (Brusaferro et al. 2008). The extent of the coenoses of the *Phragmition communis* was changeable depending on the water amount and anthropic pressure, whereas, in the outer part of the basin, there was herbaceous vegetation (Pedrotti 2019). The free waters in the central part of the basin in the mid of the reed bed hosted hydrophytic communities characterized by *Potamogeton lucens*, *Nymphaea alba*, *Persicaria amphibia*, and *Characeae* (Pedrotti 2019).

Between 1964 and 1972, the vegetation of a peat bog, composed of *Eriophorum latifolium*, *Carex panicea*, and *Juncus subnodulosus* communities, along with *Magnocaricion elatae* communities and part of *Ranunculion velutini* hay-meadows, were destroyed to plant a poplar (*Populus canadensis*) cultivation, and then drained, tilled, and subjected to peat mining (Pedrotti 1965, 1977, 2019).

From the early 1970s, when hunting was prohibited and the periodical flame weeding ceased, to the end of the 20th century, the reed doubled its surface to the detriment of hydrophytic communities and *Schoenoplectetum lacustris* (Pedrotti 1975; Orsomando 2002; Catorci et al. 2010), while the vegetation of *Trifolio-Hordeetalia* reduced its extent (Pedrotti 2019).

In the early 1990s, the thresholds of the bulkheads in front of the three main swallow holes were raised, and gaps in the helophytic vegetation were opened near the borders of the basin (Pedrotti 1996). This intervention had the positive effect of limiting the frequency of desiccation events during summer. However, in the last 20 years, the Palude di Colfiorito underwent several times desiccation, probably because of the reduction of precipitation and the increase in evapotranspiration due to the spread of the reed bed (Brusaferro et al. 2008; Catorci et al. 2010).

Since the institution of the Colfiorito Regional Park, the anthropic pressure ceased; however, the reed bed spread, closing some canals and ditches, and accumulated a great amount of litter, causing negative impacts on the wetland ecosystem (Brusaferro et al. 2008; Catorci et al. 2010). The *Nymphaeetum albae* spread as well, and a shrub formation now covers the area formerly covered by the peat bog vegetation (Pedrotti 2019).

Recently, Lastrucci et al. (2019a) recorded at the Palude di Colfiorito a net 18.8% increase in the surface of the reed bed between 1988 and 2012 due to the expansion of the reeds in terrestrial habitats formerly covered by different types of natural vegetation. However, they reported a retreat of the reed bed from the waterfront and an increasing fragmentation associated with the reed dieback process (Lastrucci et al. 2017b, 2019a).

The privately-owned lands occupied by humid hay meadows around the marsh, as well as in the other plains, are traditionally mown twice during the year (late June/early July and late August). The use of fertilizers in the surrounding arable lands has been deemed as the main cause of water eutrophication in the Palude di Colfiorito, where the quality of water between 2004 and 2011 was frequently considered as poor or bad, with low oxygen concentrations during summer (Regione Umbria 2015).

Data collection

We conducted 239 phytosociological relevés (years 2005-2009) using the Braun-Blanquet phytosociological method (Braun-Blanquet 1964). The species nomenclature followed Bartolucci et al. (2018). For each relevé, we recorded the following data: collection date, locality, altitude (m a.s.l.), slope aspect (azimuth degrees), slope angle (vertical degrees), total vegetation cover (%), and cover-abundance values of the species, the latter assigned using the Braun-Blanquet scale (Braun-Blanquet 1964). Localities are indicated in the tables (Supplementary material 1: Tables S1-S19) using the following abbreviations: An, Piano di Annifo; Ar, Piano di Arvello; Cc, Piano di Colle Croce; Co, Piano di Colfiorito; PC, Palude di Colfiorito; P, Piano di Popola e di Cesi; R, Piano di Ricciano. The dates of relevés are listed in Appendix II.

Data elaboration

We transformed Braun-Blanquet cover-abundance classes into percent values using the average cover values of Braun-Blanquet classes:

+ (< 1%), 0.5 %;
1 (1–5%), 3 %;
2 (5–25%), 15%;
3 (25–50%), 37.5%;
4 (50–75%), 62.5%;
5 (75–100%), 87.5%.
r (rare species) were attributed 0.1%.

We performed cluster analysis on the Hellinger-transformed "relevé-by-species cover" matrix, using the group average algorithm, based on euclidean distance. The Hellinger transformation is recommended for the classification and ordination of species abundance data (Rao 1995; Legendre and Gallagher 2001). To perform cluster analysis, we used R software (version 3.4.1, R Foundation for Statistical Computing, Vienna, Austria, 2017, http://www.R-project.org) and the hclust function of the *stats* R-package, version 3.4.1, as well as the vegdist function of the *vegan* R-package, version 2.4-3 (Oksanen et al. 2017). To perform the Hellinger transformation, we used the decostand function of *vegan*.

For the syntaxonomic placement of the vegetation types, we referred to Chytrý (2011), Landucci et al. (2013, 2015, 2020), Biondi and Blasi (2016), Mucina et al. (2016),

Venanzoni et al. (2018), and Ciaschetti et al. (2020). The nomenclature of alliances and higher syntaxonomic ranks was taken from Mucina et al. (2016). For nomenclature at the association level, we referred mainly to Chytrý (2011) and Landucci et al. (2020).

Finally, we compared the plant communities found in our survey with those found by other authors in the past in the study area and assessed their status as habitats of community interest sensu 92/43/EEC Directive following the Italian interpretation manual of the 92/43/EEC Directive habitats (Biondi et al. 2010).

Results

The cluster analysis of the phytosociological relevés showed the following nineteen main groups (Fig. 2), some of which were further divided into sub-clusters depending on their floristic characteristics: rooting hydrophytic communities dominated by *Myriophyllum spicatum*, *Persicaria amphibia*, *M. verticillatum*, *Nymphaea alba* (group 1, Suppl. material 1: Table S1) or *Callitriche stagnalis* (group 2, Suppl. material 1: Table S2); rooting hydrophytic communities with a dominance of *Ranunculus trichophyllus*, and helophytic vegetation with a dominance of *Glyceria notata* (group 3, Suppl. material 1: Table S3); helophytic communities dominated by *Berula erecta*, *Catabrosa aquatica*, *Veronica anagallis-aquatica*, *Nasturtium officinale* or *Helosciadium nodiflorum* (group 4, Suppl. material 1: Table S4), *Eleocharis palustris* (group 5, Suppl. material 1: Table S5), *Schoenoplectus lacustris*, *Limniris pseudacorus*, *Typha latifolia*, *Carex hirta*, *Glyceria maxima* (group 6, Suppl. material 1: Table S6), *Carex vesicaria* (group 7, Suppl. material 1: Table S7), *Juncus inflexus* subsp. *inflexus* (group 8, Suppl. material 1: Table S8); *Sambucus ebulus*-dominated perennial nitrophilous vegetation (group 9, Suppl. material 1: Table S9); helophytic communities characterized by *Carex riparia*, *Cyperus longus* or *Phragmites australis* (group 10, Suppl. material 1: Table S10); therophytic ephemeral nitrophilous communities dominated by *Xanthium italicum*, *Bidens tripartita* subsp. *tripartita* and *Persicaria lapathifolia* subsp. *lapathifolia* (group 11, Suppl. material 1: Table S11); perennial hygro-nitrophilous vegetation characterized by *Epilobium hirsutum* or *Galega officinalis* (group 12, Suppl. material 1: Table S12); grassland communities dominated by *Deschampsia cespitosa* (group 13, Suppl. material 1: Table S13) or *Ranunculus velutinus* (group 14, Suppl. material 1: Table S14); helophytic vegetation with a dominance of *Sparganium erectum* (group 15, Suppl. material 1: Table S15) or *Carex acuta* (group 16, Suppl. material 1: Table S16); *Potentilla reptans*-dominated perennial hygro-nitrophilous vegetation (group 17, Suppl. material 1: Table S17); *Phalaris arundinacea*-dominated helophytic vegetation (group 18, Suppl. material 1: Table S18); *Carex otrubae*, *Rorippa amphibia* or *Gratiola officinalis*-dominated communities (group 19, Suppl. material 1: Table S19).

Discussion

Phytosociological interpretation of plant communities

The phytosociological interpretation of plant communities highlighted by cluster analysis (Fig. 2) led to identifying 39 plant communities, described below according to their floristic, phytocoenological, and ecological features.

POTAMOGETONO PECTINATI-MYRIOPHYLLETUM SPICATI Rivas Goday 1964 (group 1, Suppl. material 1: Table S1, rels 1–2)

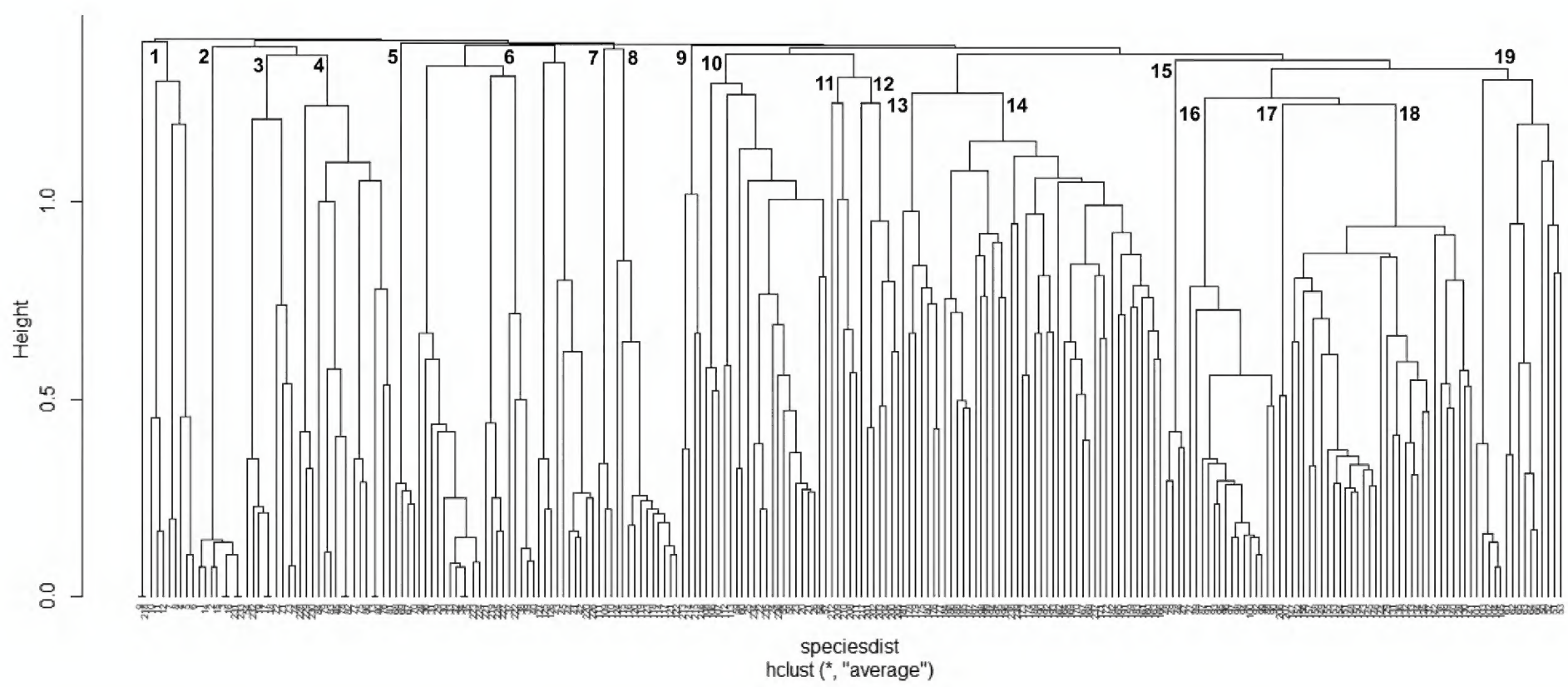

Figure 2. Dendrogram obtained from the cluster analysis of the "relevés-by-species" matrix. The cluster numbering corresponds to the table numbering in the supplementary material 1.

Hydrophytic vegetation characterized by the submerged species *Myriophyllum spicatum*, attributed to the *Potamogetono pectinati-Myriophylletum spicati* association (*Potamogetonion pectinati* alliance). This community, generally common in water bodies characterized by a high concentration of organic sediments (Barko and Smart 1986; Ceschin and Salerno 2008), is uncommon in the Palude di Colfiorito, where water depth exceeds 50 cm.

In 1967, Pedrotti found at the Palude di Colfiorito a *Myriophyllum spicatum*-dominated community, attributed to the *Myriophylletum spicati* association, which had a localized distribution (Pedrotti 2019).

The association was reported in lacustrine and fluvial environments in Italy, e.g. along the River Tiber (Lastrucci et al. 2012), at the Lakes of Massaciuccoli (Lastrucci et al. 2017c) and Martignano (Azzella et al. 2013). Although some authors (Minissale and Spampinato 1985; Pirone et al. 1997; Tomei et al. 2001; Brullo et al. 2001, 2002; Ceschin and Salerno 2008) reported *Myriophyllum spicatum* communities in central-southern Italy as *Myriophylletum spicati* and attributed them to the *Nymphaeion albae* alliance, we attributed this community to the *Potamogetonion pectinati* alliance following many European and Italian authors (e.g. Felzines 1983; Golub et al. 1991; Pedrotti 1991, 1995; Loidi et al. 1997; Brzeg and Wojterska 2001; Sburlino et al. 2008; Lastrucci et al. 2010a; Šumberová 2011a; Pedrotti 2019).

PERSICARIA AMPHIBIA community (group 1, Suppl. material 1: Table S1, rels 3–5)

Hydrophytic species-poor community dominated by *Persicaria amphibia*, with *Myriophyllum verticillatum* and ingressive species from the *Phragmito-Magnocaricetea* class (*Phragmites australis*, *Mentha aquatica* subsp. *aquatica*, and *Carex acuta*).

We found this community of the *Nymphaeion albae* alliance, in the stagnant waters of the Palude di Colfiorito, with water depth ranging from a few centimeters to 50 cm during the year.

Persicaria amphibia communities have been reported from north-eastern Italy (Sburlino et al. 2008), in Lake Bolsena (Latium) (Iberite et al. 1995), Valdichiana and along the River Arno (Tuscany) (Lastrucci et al. 2007, 2010a,b), in Umbria and Abruzzo (Buchwald 1994; Orsomando 2002; Landucci et al. 2011), and in Sicily (Brullo et al. 1994).

MYRIOPHYLLETUM VERTICILLATI Gaudet ex Šumberová in Chytrý 2011 (group 1, Suppl. material 1: Table S1, rels 6–7)

Hydrophytic vegetation characterized by *Myriophyllum verticillatum*, a submerged species occurring in meso-eutrophic waters.

This community, attributed to the *Myriophylletum verticillati* association (*Potamogetonion pectinati* alliance), occurs in habitats in an advanced stage of terrestrialization (Šumberová 2011b) and is quite common in stagnant waters of the Palude di Colfiorito (water depth ranging from a few centimeters to more than half a meter). This community was sporadic at the end of the 1960s (Pedrotti 2019). In Italy, this association is uncommon, occurring in Latium (Ceschin and Salerno 2008), Tuscany (Lastrucci et al. 2016), and Sicily (Brullo et al. 1994, 2002; Raimondo et al. 2000).

NYMPHAEETUM ALBAE Vollmar 1947 (group 1, Suppl. material 1: Table S1, rels 8–10)

Species-poor hydrophytic vegetation, dominated by *Nymphaea alba*, sometimes with *Myriophyllum verticillatum* and *Persicaria amphibia*. Following Šumberová (2011a) and Tomaselli et al. (2006), we attributed this community to the *Nymphaeetum albae* Vollmar 1947 association (*Nymphaeion albae* alliance). We found this community in the stagnant waters of the Palude di Colfiorito, 0.5-1 m-deep, where it forms very extensive stands. This is consistent with Šumberová (2011a), who stated that this association significantly contributes to water body filling by its high biomass production.

According to Pedrotti (1975, 2019), *Nymphaea alba* occurred in the 1960s inside the subassociation *Myriophyllo-Potamogetonetum lucentis nymphaeetosum*.

The association was reported at the Lake of Massaciuccoli (Tuscany) by Lastrucci et al. (2017c), in Piedmont (Guglielmetto Mugion and Montacchini 1993-1994), Lombardy (Andreis and Zavagno 1996), Veneto (Anoè and Caniglia 1987), Trentino (Canullo et al. 1990), and Friuli-Venezia Giulia (Poldini 1989).

CALLITRICHE STAGNALIS community (group 2, Suppl. material 1: Table S2)

Hydrophytic vegetation dominated by *Callitriche stagnalis*, with *Ranunculus trichophyllus*, of the *Ranunculion aquatilis* alliance, with ingressive species from *Nasturtio-Glycerietalia* (*Nasturtium officinale*, *Helosciadium nodiflorum*, *Veronica anagallis-aquatica*, and *Berula erecta*).

We found this community in stagnant or slowly flowing waters of ditches; toward the banks, it was in contact with the helophytic vegetation of the *Helosciadietum nodiflori*, *Nasturtietum officinalis*, and *Veronica anagallis-aquatica* community.

Pedrotti (2019) found in the outer part of the Palude di Colfiorito, along spring-fed ditches, the *Veronico beccabungae-Callitrichetum stagnalis* Müller 1962, which differs from our relevés for the presence of *Veronica beccabunga* and *Glyceria fluitans*.

In accordance with some Italian authors (e.g. Corbetta and Pirone 1989; Baldoni and Biondi 1993; Venanzoni and Gigante 2000), we did not attribute *C. stagnalis*-dominated communities to the association *Callitrichetum stagnalis* Segal 1967, given their low floristic richness.

In Italy *C. stagnalis*-dominated communities have been found in the Venetian Plain (Marchiori and Sburlino 1997), Tuscany, Marche, Umbria, Latium, and Abruzzo (Corbetta and Pirone 1989; Baldoni and Biondi 1993; Buchwald 1994; Venanzoni and Gigante 2000; Ceschin and Salerno 2008; Lastrucci and Becattini 2008; Mereu et al. 2010), and in Sardinia (Biondi and Bagella 2005).

POTAMOGETONO CRISPI-RANUNCULETUM TRICHOPHYLLI Imchenetzky 1926 (group 3, Suppl. material 1: Table S3, rels 1–5)

Ranunculus trichophyllus-dominated hydrophytic community, with *Callitriche stagnalis*, referred to the *Ranunculion aquatilis* alliance. The species composition included elements of the *Glycerio-Sparganion* alliance and higher-rank syntaxa (e.g. *Nasturtium officinale*, V*eronica anagallis-aquatica*, and *Glyceria notata*).

The association is uncommon in the stagnant or slowly flowing waters along ditches.

In Italy, *Ranunculus trichophyllus*-dominated communities were found in northeastern and central Italy, and in Sicily (e.g. Ferro 1980; Corbetta and Pirone 1989; Buchwald 1994; Gerdol and Tomaselli 1997; Tomei et al. 2001; Pirone et al. 2004; Tomasi and Caniglia 2004; Lastrucci et al. 2010a; Landucci et al. 2011).

GLYCERIETUM NOTATAE Kulczyński 1928 (group 3, Suppl. material 1: Table S3, rels 6–9)

Species-poor plant community, physiognomically characterized by *Glyceria notata* and other species of the *Glycerio-Sparganion* alliance and higher syntaxa (e.g. *Veronica anagallis-aquatica*, *Nasturtium officinale*, *Mentha aquatica* subsp. *aquatica*, and *Myosotis scorpioides*) and ingressive species from the *Potamogetonetea* class (*Ranunculus trichophyllus*).

The association is widespread in the ditches, in contact with the *Nasturtietum officinalis* association and the *Veronica anagallis-aquatica* community. In the sections with slow flowing water, it was found at the border of the watercourse, toward the inside, in contact with the *Potamogetono crispi-Ranunculetum trichophylli*. Where water is stagnant for most of the year, the community occupies the ditch bed, together with the *Caricetum vesicariae* and *Phalaridetum arundinaceae* associations.

In Italy this vegetation type is frequent, being recorded by many authors from sea level to the mountain belt (e.g. Cortini Pedrotti et al. 1973; Canullo et al. 1988; Corbetta and Pirone 1989; Pedrotti et al. 1992; Baldoni and Biondi 1993; Buchwald 1994; Pedrotti 1995; Marchiori and Sburlino 1997; Scoppola 1998; Biondi et al. 1999; Lastrucci et al. 2004; Pedrotti 2008).

BERULETUM ERECTAE Roll 1938 (group 4, Suppl. material 1: Table S4, rels 1–3)

Helophytic vegetation characterized by *Berula erecta*, with species of the *Glycerio-Sparganion* alliance and higher syntaxa (*Glyceria notata*, *Veronica anagallis-aquatica*, and *Nasturtium officinale*).

In the study area, it occurs along the ditches of the Palude di Colfiorito, near the banks of the deepest ones, where it is in contact with *Helosciadietum nodiflori*, towards the central part of the ditch section.

This community (syn. *Veronico-Sietum erecti* Passarge 1982, *Veronico beccabungae-Beruletum erectae* Passarge 1999) was found by Prosser and Sarzo (2003) and Pedrotti (1995) in Trentino, Pedrotti (2008) in the "Marcite di Norcia" (Umbria), by Ceschin and Salerno (2008) along the Rivers Tevere, Aniene and Treia (Latium), and in Molise (Canullo et al. 1988).

RORIPPO ANCIPITIS-CATABROSETUM AQUATICAE (Oberdorfer 1957) Müller et Görs 1961 (group 4, Suppl. material 1: Table S4, rel. 4)

Plant community with a dominance of *Catabrosa aquatica*, with *Veronica anagallis-aquatica*, *Glyceria notata*, and *Helosciadium nodiflorum*, growing on slow-flowing or temporarily stagnant waters. It hosts some species of the *Molinio-Arrhenatheretea* class, such as *Holcus lanatus*, *Poa pratensis* and *Dactylis glomerata*, because it is in contact with the temporarily flooded meadows of the *Ranunculion velutini* alliance. Following Landucci et al. (2020), the composition of this community fits with that of the *Rorippo ancipitis-Catabrosetum aquaticae* association (*Glycerio-Sparganion* alliance).

We found this community along the main ditch that crosses the Piano di Colle Croce.

The *Catabrosa aquatica* community found along the River Nera (Marche, central Italy) by Buchwald (1994), which was attributed to the *Catabrosetum aquaticae* Rübel 1911, should be referred to this association.

VERONICA ANAGALLIS-AQUATICA SUBSP. *AQUATICA* community (group 4, Suppl. material 1: Table S4, rels 5–9)

Veronica anagallis-aquatica-dominated community, with *Nasturtium officinale* and some ingressive species from the *Molinio-Arrhenatheretea* and *Bidentetea* classes. The occurrence of *Veronica anagallis-aquatica* and *Nasturtium officinale* justifies its placement in the *Glycerio-Sparganion* alliance.

The community was found in stagnant or slightly flowing waters, 20-50 cm deep, in contact with *Nasturtietum officinalis* and the *Callitriche stagnalis* community.

NASTURTIETUM OFFICINALIS Gilli 1971 (group 4, Suppl. material 1: Table S4, rels 10–12)

Single-species or species-poor pioneer helophytic community, which establishes after human disturbance, with a dominance of *Nasturtium officinale*, with *Veronica anagallis-aquatica* and ingressive species from *Molinio-Arrhenatheretea*.

This community, typical of sunny, quickly to slowly flowing, oligo- to eutrophic waters (Buchwald 1994), is distributed in small stands along the ditches that cross cultivated lands, in contact with *Helosciadietum nodiflori*, *Glycerietum notatae*, *Callitriche stagnalis* community, and *Veronica anagallis-aquatica* community.

In Italy, this community is widely spread (e.g. Barberis and Mariotti 1981; Canullo et al. 1988; Géhu and Biondi 1988; Corbetta and Pirone 1989; Baldoni and Biondi 1993; Pedrotti 1995; Biondi et al. 1997; Pirone et al. 1997; Scoppola 1998; Bracco et al. 2000; Brullo et al. 2002; Prosser

and Sarzo 2003; Tomasi and Caniglia 2004; Ceschin and Salerno 2008; Pedrotti 2008; Lastrucci et al. 2010b, 2012, 2016, 2017c).

HELOSCIADIETUM NODIFLORI Maire 1924 (group 4, Suppl. material 1: Table S4, rels 13–16)

Vegetation of ditches characterized by *Helosciadium nodiflorum* with elements of the *Glycerio-Sparganion* alliance and the *Nasturtio-Glycerietalia* order (*Nasturtium officinale*, *Veronica anagallis-aquatica*, *Berula erecta*, and *Glyceria notata*).

We found this community along a short stretch of a ditch at the Palude di Colfiorito, in contact with *Beruletum erectae* and *Nasturtietum officinalis*, where water was 50-60 cm deep.

The association is rather frequent in Italy (e.g. Pedrotti, 1967, 1995, 2008; Canullo et al. 1988; Baldoni and Biondi 1993; Buchwald 1994; Pirone et al. 1997; Brullo et al. 2001, 2002; Prosser and Sarzo 2003; Biondi and Bagella 2005; Sburlino et al. 2008; Mereu et al. 2010; Lastrucci et al. 2016).

ELEOCHARITETUM PALUSTRIS Savič 1926 (group 5, Suppl. material 1: Table S5)

Single-species or species-poor pioneer plant community, physiognomically characterized by *Eleocharis palustris* subsp. *palustris*, sometimes associated with species of the *Molinio-Arrhenatheretea* class, coming from the surrounding meadows. The community develops where the soil is subject to periodic cycles of submergence and emergence until the end of spring and can tolerate long periods of flooding, but it can also withstand periods with dry soil (Šumberová 2011a).

We found this association in small patches at the edge of Palude di Colfiorito, in contact with communities referred to *Phragmition communis* and *Bidention tripartitae* alliances.

This vegetation type is distributed in northern and central Italy (e.g. Pedrotti et al. 1992; Buchwald 1994; Mariotti 1995; Biondi et al. 1997; Venanzoni and Gigante 2000; Tomei et al. 2001; Landi et al. 2002; Angiolini et al. 2003; Lastrucci et al. 2007, 2010a,b, 2012, 2019b).

SCHOENOPLECTETUM LACUSTRIS Chouard 1924 (group 6, Suppl. material 1: Table S6, rels 1–11)

Community characterized by *Schoenoplectus lacustris*, mostly occurring in the outer vegetation belt of the Palude di Colfiorito, where it forms dense and extensive monospecific stands between *Phragmitetum/Phalaridetum* and open waters. Where the stands are less dense, other species of the *Phragmition communis* alliance and higher-rank syntaxa, including *Phragmites australis*, *Phalaris arundinacea*, and *Typha latifolia*, enter into the composition of this community.

The *Schoenoplectetum lacustris* is in close contact with other associations of the *Phragmition communis* alliance, especially in the Palude di Colfiorito, and sometimes occupies the whole section of unmanaged ditches.

The association is rather frequent across Italy in marshes, around lakes and along watercourses (Fascetti et al. 1989; Poldini 1989; Brullo et al. 1994; Iberite et al. 1995; Venanzoni and Gigante 2000; Merloni and Piccoli 2001; Landi et al. 2002; Venanzoni et al. 2003; Lastrucci et al. 2007; Ceschin and Salerno 2008; Lastrucci et al. 2019b).

IRIDETUM PSEUDACORI Eggler 1933 ex Brzeg et M. Wojterska 2001 (group 6, Suppl. material 1: Table S6, rels 12–15)

Plant community with a dominance of *Limniris pseudacorus*, with species of the *Phragmition communis* alliance (e.g. *Typha latifolia* and *Schoenoplectus lacustris*) and ingressive species from the *Molinio-Arrhenatheretea* class, coming from the surrounding meadows.

We found this association inside depressions in the humid meadows and along some ditches of the Piano di Colfiorito.

Limniris pseudacorus-dominated communities had been found in various Italian wetlands from the Trentino-Alto Adige to Sicily (e.g. Brullo et al. 1994; Pedrotti 1995; Pirone et al. 1997; Raimondo et al. 2000; Arrigoni and Papini 2003; Prosser and Sarzo 2003; Maiorca et al. 2005; Presti et al. 2005; Ceschin and Salerno 2008; Lastrucci et al. 2010a,b, 2016).

TYPHETUM LATIFOLIAE Nowiński 1930 (group 6, Suppl. material 1: Table S6, rels 16–20)

Species-poor plant community, characterized by *Typha latifolia*, associated with other species of the *Phragmition communis* alliance (*Schoenoplectus lacustris* and *Glyceria maxima*).

Typhetum latifoliae occurs in stagnant or slowly flowing waters of marshes and ditches, less than 50 cm deep, in contact with other associations of *Phragmito-Magnocaricetea* and, to the inside of the basins and ditches, with the hydrophytic coenoses of *Potamogetonetea*.

It is very common in Italian wetlands (e.g. Martini and Poldini 1980; Corbetta and Pirone 1989; Baldoni and Biondi 1993; Biondi and Baldoni 1994; Buchwald 1994; Biondi et al. 1997; Bracco et al. 2000; Venanzoni and Gigante 2000; Viciani and Raffaelli 2003; Prosser and Sarzo 2004; Ceschin and Salerno 2008; Lastrucci et al. 2010a,b, 2012).

CAREX HIRTA community (group 6, Suppl. material 1: Table S6, rels 21–23)

Species-poor plant community, with a dominance of *Carex hirta*. Due to the occurrence of elements of *Potentillion anserinae* and higher-rank syntaxa, we placed this community in the *Potentillion anserinae* alliance, even though the presence of some elements of the *Phragmito-Magnocaricetea* class marks its transition towards the coenoses of flooded habitats. Because of the lack of floristic characterization, we could not classify it at the association level.

Toward the inside of the basins, this community is in contact with helophytic communities of *Phragmition*

communis and *Magnocaricion gracilis*, and toward the external areas, with *Ranunculion velutini* meadows.

In Tuscany, Lastrucci et al. (2019b) found a community characterized by *Carex hirta* and *C. otrubae*, in fresh, partially shaded and not submerged soils. Biondi and Ballelli (1995) described in Umbria a *Carex hirta*-dominated association, the *Ranunculo acri-Caricetum hirtae*, which was found by Ciaschetti et al. (2020) in the highlands of Abruzzo. However, in our opinion there are not enough elements to attribute this community to this association, because all the diagnostic species except *Carex hirta* are absent (*Carex leporina*, *Ranunculus acris*, *R. repens,* and *Alopecurus rendlei*).

GLYCERIETUM MAXIMAE Nowiński 1930 corr. Šumberová, Chytrý et Danihelka in Chytrý 2011 (group 6, Suppl. material 1: Table S6, rels 24–30)

Species-poor plant community of marshes and ditches, with a dominance of *Glyceria maxima*, which is associated with other species of the *Phragmition communis* alliance and higher syntaxa, including *Phragmites australis*, *Phalaris arundinacea*, *Alisma plantago-aquatica*, *Sparganium erectum*, and *Lycopus europaeus*.

The community forms more or less extensive stands in the outer part of the Palude di Colfiorito basin, where, according to Pedrotti and Murrja (2020) is reducing its extent, and in small parts of some ditches in other plains, in contact with the associations of the *Phragmition communis* and *Glycerio-Sparganion* alliances.

In Italy this vegetation type is reported from lowland to submontane areas of northern and central Italy (e.g. Pedrotti 1965; Gerdol et al. 1979; Arrigoni and Ricceri 1982; Piccoli and Gerdol 1982; Marchiori and Sburlino 1986; Pedrotti 1995; Sartori and Bracco 1997; Catorci and Orsomando 2001; Lastrucci et al. 2010b, 2014).

CARICETUM VESICARIAE Chouard 1924 (group 7, Suppl. material 1: Table S7)

Species-poor, sometimes monospecific helophytic community, dominated by *Carex vesicaria*, belonging to the *Magnocaricion gracilis* alliance, with a few other species of *Phragmito-Magnocaricetea* class (e.g. *Typha latifolia*, *Glyceria notata*, and *Rorippa amphibia*), typical of stagnant waters and marshy meadows, which grows on meso-eutrophic, mineral or semi-peaty soils (Mierwald 1988).

The association is uncommon in the study area and occurs along a short stretch of the main ditch of the Piano di Arvello.

The association had been found in wetlands of northern and central Italy (Cortini Pedrotti et al. 1973; Martini and Poldini 1980; Montanari and Guido 1980; Pirone 1987; Marchiori et al. 1993; Buchwald 1994; Gerdol and Tomaselli 1997; Marchiori and Sburlino 1997; Rossi and Alessandrini 1998; Prosser and Sarzo 2003; Lastrucci et. al. 2008).

CARICI OTRUBAE-JUNCETUM INFLEXI Minissale et Spampinato 1985 (group 8, Suppl. material 1: Table S8)

Species-poor sub-nitrophilous and sub-hygrophilous community dominated by *Juncus inflexus* subsp. *inflexus*, associated with species of the *Potentillo-Polygonetalia* order and *Molinio-Arrhenateretea* class, e.g. *Carex otrubae*, *Ranunculus repens*, *Carex hirta*, *Galium album* subsp. *album*, and *Rumex acetosa*. The species composition of the community allows us to place it in the *Potentillo-Polygonetalia* order of the *Molinio-Arrhenateretea* class. This is consistent with Landucci et al. (2020), who excluded *Juncus inflexus* communities from the *Phragmito-Magnocaricetea* vegetation in Europe.

The species composition of this community differs from that of *Galio palustris-Juncetum inflexi*, described by Venanzoni and Gigante (2000), because of the absence of *Galium palustre* and *Scutellaria galericulata* and the prevalence of species of the *Molinio-Arrhenatheretea* class. It also differs from the *Mentho longifoliae-Juncetum inflexi* Lohmeyer ex Oberdorfer 1957 asssociation because *Mentha longifolia*, characteristic of the association, is absent. Because of the dominance of the helophyte *Juncus inflexus* subsp. *inflexus* and the presence of *Carex otrubae*, we attributed this community to the *Carici otrubae-Juncetum inflexi*, described at Lake Gurrida in northeastern Sicily by Minissale and Spampinato (1985) and found in Calabria (Maiorca et al. 2005) and Tuscany (Lastrucci et al. 2019b).

The association is in contact with some communities of *Phragmition communis*, i.e. *Phalaridetum arundinaceae*, *Schoenoplectetum lacustris*, *Glycerietum maximae*, and with the humid meadows of the *Ranunculion velutini* alliance. The other contact vegetation is the *Carex otrubae* community, toward the banks of some ditches subjected to periodic desiccation.

URTICO DIOICAE-SAMBUCETUM EBULI (Br.-Bl. in Br.-Bl., Gajewski, Wraber et Wa1as 1936) Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 (group 9, Suppl. material 1: Table S9)

Thermo-heliophilous and nitrophilous association, characterized by *Sambucus ebulus*, with *Urtica dioica* and species of the *Balloto-Conion maculati* alliance and higher syntaxa, such as *Conium maculatum*, *Rubus caesius*, *Cruciata laevipes*, *Galium aparine*, and ingressive species from *Molinio-Arrhenatheretea*.

The association occurs sporadically on nitrogen-rich soils, at the edge of roads, paths, and hedges around the wetlands.

This association has been found in northern (Poldini 1980; Tomaselli et al. 2006), central (Biondi and Ballelli 1982; Lastrucci et al. 2010a,b, 2014), and southern Italy (Brullo et al. 1998; Maiorca and Spampinato 1999).

CARICETUM RIPARIAE Máthé et Kovács 1959 (group 10, Suppl. material 1: Table S10, rels 1–3)

Species-poor *Carex riparia*-dominated community, with a low number of *Phragmito-Magnocaricetea* species and ingressive elements from the *Molinio-Arrhenatheretea* class. The occurrence of *C. acuta* and *C. vesicaria*, besides the dominant species, allows its attribution to the community of the *Caricetum ripariae* association, included in

the *Magnocaricion gracilis* alliance, following Landucci et al. (2020).

This community is very fragmented and forms dense stands in marshy meadows and ditches, in contact with the communities of the *Phragmition communis* and *Magnocaricion gracilis* alliances.

This association is rather frequent, but endangered, across the Italian Peninsula (e.g. Anoè and Caniglia 1987; Orsomando 1993; Pirone et al. 1997; Sartori and Bracco 1997; Prosser and Sarzo 2004; Landucci et al. 2013; Lastrucci et al. 2014, 2016) and Sicily (Brullo et al. 1998, 2002).

CYPERETUM LONGI (Micevski 1957) Micevski 1963 (group 10, Suppl. material 1: Table S10, rels 4–5)

Community characterized by *Cyperus longus*, poor in elements of the *Phragmito-Magnocaricetea* class, with several ingressive species from *Molinio-Arrhenatheretea*.

Because of the dominance of *Cyperus longus* and the presence of species of the *Phragmito-Magnocaricetea* and *Molinio-Arrhenatheretea* classes, following Landucci et al. (2020), this plant community fits with the *Cyperetum longi* association (*Phragmition communis* alliance).

This community is uncommon in the study area, where it forms small and dense stands, in periodically flooded soils, in contact with *Phragmitetum australis* and the communities of the *Ranunculion velutini* alliance.

In Italy, the association was found in Tuscany (Lastrucci et al. 2010a,b, 2016), Umbria (Venanzoni and Gigante 2000; Pedrotti 2008; Lastrucci et al. 2012), Abruzzo (Corbetta and Pirone 1989; Pirone et al. 2003), Molise (Paura et al. 2004), Basilicata (Venanzoni et al. 2003), and Sicily (Brullo et al. 1994).

PHRAGMITETUM AUSTRALIS Savič 1926 (group 10, Suppl. material 1: Table S10, rels 6–21)

Helophytic single-species or species-poor community, dominated by *Phragmites australis*, attributed to the *Phragmitetum australis* association, including species of the *Phragmition communis* alliance and higher syntaxa, as well as ingressive elements from the *Molinio-Arrhenatheretea* and *Artemisietea vulgaris* classes.

It is the dominant type of vegetation in the Palude di Colfiorito, where it develops in stagnant eutrophic waters with ground flooded from autumn to early summer and not drying in summer. In the other plains, this association occurs in the bed of the ditches.

If it is not subjected to periodic disturbance (mowing or tillage), this community tends to colonize the marshy and humid meadows in the outer vegetation band of the Palude di Colfiorito and the uncultivated lands in contact with the wetland vegetation (Catorci et al. 2010). Lastrucci et al. (2019a) documented the increasing fragmentation related to the dieback process of the reed bed along the waterfront and the expansion of the reeds in terrestrial habitats formerly occupied by different types of natural vegetation. *Phragmites australis* is in fact a highly competitive species, which can invade other plant communities in the absence of disturbance. This colonization process was observed for the *Carex panicea* peaty meadow community, which once had spread over a large area in the south-western part of the Palude di Colfiorito (Pedrotti 1975) and has disappeared as a consequence of competition with *Phragmites australis*. In fact, relevés carried out in the area formerly occupied by the *C. panicea* community (Pedrotti 2019), with very rare and interesting species from a biogeographical and conservation viewpoint, such as *Dactylorhiza incarnata* and *Epipactis palustris*, were grouped by the cluster analysis among those of *Phragmitetum australis*, indicating a dynamic stage of vegetation. Nowadays, this area is almost completely invaded by shrubs (Pedrotti 2019).

To the inside of the basin, the community is in contact with the hydrophytic communities of the *Nymphaeion* alliance, while to the outside of the basin, it is in contact with other *Phragmito-Magnocaricetea* and *Molinio-Arrhenatheretea* communities, with which it sometimes forms compenetrations.

The association is very common in all the countries of the temperate zone, including Italy (e.g. Corbetta and Pirone 1989; Baldoni and Biondi 1993; Buchwald 1994; Iberite et al. 1995; Pirone et al. 1997; Venanzoni and Gigante 2000; Arrigoni and Papini 2003; Ceschin and Salerno 2008; Lastrucci et al. 2010a,b, 2012, 2017c, 2019b). In particular, in the Palude di Fucecchio, Lake Chiusi (Tuscany), Lake Vico (Latium), Lake Trasimeno, and Palude di Colfiorito (Umbria), Lastrucci et al. (2017a) described seven variants, four of which (with *Myriophyllum spicatum*, *Schoenoplectus lacustris*, *Calystegia sepium*, and *Urtica dioica*) were found at the Palude di Colfiorito.

POLYGONO LAPATHIFOLII-XANTHIETUM ITALICI Pirola et Rossetti 1974 (group 11, Suppl. material 1: Table S11, rel. 1)

Therophytic ephemeral plant community, which appears in late-summer in temporarily flooded nutrient-rich and silty-sandy soils, characterised by species of the *Bidentetea tripartitae* class and ingressive elements from Stellarietea mediae and *Artemisietea vulgaris* classes. Because of the dominance of *Xanthium italicum* and the occurrence of *Persicaria lapathifolia*, we attributed it to the *Polygono lapathifolii-Xanthietum italici* association (*Chenopodion rubri* alliance).

The very fragmented stands of this association (sometimes extended a few square meters) occur on the external edge of humid meadows, in contact with croplands.

The association is known for the border of water basins on silty-sandy nitrophilous soils (Lastrucci and Becattini 2008; Sciandrello 2009), but it is more common along watercourses in northern Italy (Liguria, Lombardia, Emilia Romagna), central Italy, Molise, Sicily (e.g. Mariotti 1995; Assini 1997; Sartori and Bracco 1997; Biondi et al. 1997, 1999, 2004; Brullo et al. 2002; Paura et al. 2004; Ceschin and Salerno 2008; Lastrucci et al. 2010b; Crisanti and Taffetani 2015).

BIDENTETUM TRIPARTITAE Miljan 1933 (group 11, Suppl. material 1: Table S11, rels 2–5)

Therophytic ephemeral plant community of temporarily flooded, nutrient-rich areas, which appears in the late summer, characterized by the annual species *Bidens tripartita* subsp. *tripartita* and *Persicaria lapathifolia*, characteristic of the association *Bidentetum tripartitae* and higher syntaxa, and transgressive species from *Potentillion anserinae* alliance.

The very fragmented stands of this association, sometimes extended a few square meters, occur at the edge of marshy and humid meadows, which are flooded until late spring-early summer and emerge in mid-late summer.

Two variants of this association, characterized by *Persicaria lapathifolia* and *Chenopodiastrum murale* were found by Pedrotti and Murrja (2020) in the eastern part of the Palude di Colfiorito.

In Italy, it was found in northern and central Italy and Sicily (Martini and Poldini 1980; Marchiori et al. 1993; Biondi et al. 1999, 2003; Sarzo et al. 1999; Brullo et al. 2002; Pirone et al. 2003; Prosser and Sarzo 2004).

EPILOBIUM HIRSUTUM community (group 12, Suppl. material 1: Table S12, rel. 1)

Epilobium hirsutum-dominated nitrophilous community found at the edge of the humid meadows of *Ranunculion velutini*. Given that most of the species of this community are characteristic of *Potentillion anserinae* and higher syntaxa, e.g. *Ranunculus repens*, *Galega officinalis*, and *Lotus corniculatus*, we placed it in the *Potentillion anserinae* alliance.

GALEGA OFFICINALIS community (group 12, Suppl. material 1: Table S12, rels 2–7)

Nitrophilous pioneer community, physiognomically characterized by *Galega officinalis*, including species of the *Potentillion anserinae* alliance and higher syntaxa, e.g. *Ranunculus repens*, *Galium album* subsp. *album*, and *Poa trivialis*. The occurrence of ingressive species from the *Phragmito-Magnocaricetea*, *Stellarietea mediae*, and *Artemisietea vulgaris* classes indicates the placement of this community between the helophytic vegetation of *Phragmition communis* / *Magnocaricion gracilis* and anthropogenic vegetation.

This community occurs along the banks of ditches at the borders of the plains, periodically flooded during the year, with alternation of a flooding phase in winter and spring and a summer emergence phase.

Venanzoni and Gigante (2000) described in the Lakes Trasimeno and Alviano (Umbria) the *Cirsio triumfetti-Galegetum officinalis* association, placed in the *Potentillion anserinae* alliance. Compared to that association, our relevés lack *Cirsium creticum* subsp. *triumfettii*, *Convolvulus sepium*, and *Lotus tenuis*, characteristic species of this association. However, we did not find enough elements to describe a new association.

Pedrotti and Murrja (2020) found a similar community in the eastern part of the Palude di Colfiorito and referred it to the *Cirsio triumfetti-Galegetum officinalis* association; however, in our opinion, this attribution is doubtful because it lacks the characteristic species except *C. creticum* subsp. *triumfettii*.

DESCHAMPSIO-CARICETUM DISTANTIS Pedrotti 1976 (group 13, Suppl. material 1: Table S13)

Thick-sward wet meadows, dominated by *Deschampsia cespitosa*. The occurrence of *Ranunculus velutinus*, *Lolium arundinaceum* subsp. *arundinaceum*, *Orchis laxiflora*, *Bellevalia romana*, *Trifolium resupinatum*, and *Alopecurus rendlei* justifies placing the community in the *Ranunculion velutini* alliance and the *Trifolio-Hordeetalia* order. The occurrence of *Carex distans*, besides *Deschampsia cespitosa*, allows its attribution to the *Deschampsio-Caricetum distantis* association, described by Pedrotti (1976) in the nearby Piani di Montelago (Marche).

This community, found in depressions flooded until early summer and moist until the end of summer, is in contact with *Hordeo-Ranunculetum velutini* meadows, inside which it sometimes forms more or less extended patches, and with communities of the *Phragmitetalia* and *Nasturtio-Glycerietalia* orders.

The association is endemic of the humid meadows of central and southern Italy (Pedrotti 1975; 1976; Canullo et al. 1988; Pedrotti el al. 1992; Pirone 1997; Catorci and Orsomando 2001; Tardella et al. 2002).

HORDEO-RANUNCULETUM VELUTINI Pedrotti 1976 (group 14, Suppl. material 1: Table S14)

Community of humid hay meadows with a dense sward, common in areas that remain flooded until early spring, while the ground dries up in the early summer. It is physiognomically characterized by *Ranunculus velutinus*, *Cynosurus cristatus*, *Poa pratensis* subsp. *pratensis*, *Centaurea jacea* subsp. *jacea*, and *Trifolium pratense*. The occurrence of *Lolium arundinaceum* subsp. *arundinaceum*, *Orchis laxiflora*, and *Gaudinia fragilis*, besides *Ranunculus velutinus*, justify placing the community in the *Ranunculion velutini* alliance and the *Trifolio-Hordeetalia* order, while the presence of *Hordeum secalinum*, *Bromus racemosus* subsp. *racemosus*, *Trifolium dubium*, *T. resupinatum*, *Alopecurus rendlei*, and *Bellevalia romana* indicates that the community fits with the association *Hordeo-Ranunculetum velutini*.

This association is in contact with the helophytic associations of *Phragmito-Magnocaricetea* toward the inside of the basins, and with the therophytic nitrophilous communities, and croplands, toward the outside.

This association, described by Pedrotti (1976) in the nearby Piani di Montelago (Marche), is endemic to the central and southern Apennines (Pedrotti 1967, 1975; Canullo et al. 1988; Pedrotti et al. 1992; Venanzoni 1992; Catorci and Orsomando 2001; Tardella et al. 2002).

SPARGANIETUM ERECTI Roll 1938 (group 15, Suppl. material 1: Table S15)

Plant community dominated by *Sparganium erectum*, which forms more or less thick stands. The dominant species and the presence of elements of the *Glycerio-Spargan-*

ion alliance led us to attribute this community, following Venanzoni and Gigante (2000), Lastrucci et al. (2010b), and Pedrotti (2019), to the *Sparganietum erecti* association.

We found the plant community in stagnant waters, 10-50 cm deep, in contact with *Phragmitetum australis* and *Glycerietum maximae*.

It has been reported in northern, central, and southern Italy (e.g. Marchiori and Sburlino 1986, 1997; Corbetta and Pirone 1990; Baldoni and Biondi 1993; Buchwald 1994, Pedrotti 1995; Brullo et al. 1998; Venanzoni and Gigante 2000; Prosser and Sarzo 2003; Venanzoni et al. 2003; Ceschin and Salerno 2008; Lastrucci et al. 2010b, 2012, 2016, 2017c).

CARICETUM GRACILIS Savič 1926 (group 16, Suppl. material 1: Table S16)

Species-poor helophytic association, characterized by *Carex acuta*, which forms thick stands, with species of the *Magnocaricion gracilis* alliance and higher syntaxa (*Carex vesicaria*, *Galium palustre* subsp. *elongatum*, *Phalaris arundinacea*, etc.) and sporadic occurrences of ingressive species of the *Potentillo-Polygonetalia* and *Trifolio-Hordeetalia* orders (*Molinio-Arrhenatheretea* class).

The association occurs where the soil is frequently flooded from autumn to spring and remains muddy during summer, often in contact with other communities of the *Phragmito-Magnocaricetea* class.

This community is more frequent in northern Italy, but is recorded from several localities across the Italian peninsula (e.g. Cortini Pedrotti et al. 1973; Martini and Poldini 1980; Marchiori and Sburlino 1986; Marchiori et al. 1993; Venanzoni 1988; Buffa et al. 1995; Pirone and Tammaro 1995; Marchiori and Sburlino 1997; Sartori and Bracco 1997; Bracco et al. 2000; Prosser and Sarzo 2003).

POTENTILLA REPTANS community (group 17, Suppl. material 1: Table S17)

Species-poor hygro-nitrophilous plant community, dominated by *Potentilla reptans*.

The prevalence of floristic elements of *Potentillion anserinae* and higher syntaxa (*Potentilla reptans*, *Rumex crispus*, *Oenanthe fistulosa*, and *Thalictrum lucidum*) led us to place this community in the *Potentillion anserinae* alliance.

This community differs in species composition from *Rorippo amphibiae-Potentilletum reptantis* described in Valdichiana (Tuscany, Italy) by Lastrucci et al. (2010a), because of the absence of *Rorippa amphibia*, *R. prostrata*, *Bolboschoenus maritimus*, and *Oenanthe silaifolia*; however, there are no elements to describe a new association.

The *Potentilla reptans* community is generally present on the bottom of the sinkholes, in contact with *Phalaris arundinacea* and *Carex acuta*-dominated stands.

PHALARIDETUM ARUNDINACEAE Libbert 1931
TYPICUM (group 18, Suppl. material 1: Table S18, rels 1–15; *holotypus* Table 1, rel. 2 in Libbert 1931)
ALOPECURETOSUM BULBOSI subass. nova (group 18, Suppl. material 1: Table S18, rels 16–31, *holotypus* relevé 30)
CAREX ACUTA VARIANT (group 18, Suppl. material 1: Table S18, rels 16–24)

Helophytic association dominated by *Phalaris arundinacea*, with other species of *Phragmito-Magnocaricetea* (e.g. *Phragmites australis*, *Scutellaria galericulata*, *Eleocharis palustris*, *Lythrum salicaria*, and *Carex acuta*) and ingressive species from *Molinio-Arrhenatheretea* (e.g. *Lolium arundinaceum* subsp. *arundinaceum*, *Centaurea jacea* subsp. *jacea*, and *Trifolium pratense*). The species composition allows us to place this community in the *Phragmition communis* alliance (*Phragmitetalia* order, *Phragmito-Magnocaricetea* class), following Landucci et al. (2020).

The association is rather frequent across the Italian peninsula (e.g. Bracco 1981; Marchiori et al. 1993; Buchwald 1994; Venanzoni and Gigante 2000; Arrigoni and Papini 2003; Prosser and Sarzo 2003; Tomasi and Caniglia 2004; Lastrucci et al. 2007, 2010a,b, 2014; Ceschin and Salerno 2008).

The typical form of this community was found in sites with stagnant eutrophic waters, at the edge of ditches and swallow holes, characterized by seasonal fluctuations, in contact with other helophyitic coenoses of *Phragmito-Magnocaricetea* to the inside of the basin and the main ditches, and with wet meadows of *Trifolio-Hordeetalia*, hygro-nitrophilous communities and croplands to the outside.

In the areas where water is drained more rapidly by larger canals to foster the mowing of the surrounding hay meadows, and the soil remains waterlogged and humid for a shorter period, the species composition of the community changes, increasing species from the *Molinio-Arrhenatheretea* class. The occurrence of this group of species indicates the transition from *Phalaridetum arundinaceae* to humid meadows of *Ranunculion velutini* and allows us to describe the new subassociation *Phalaridetum arundinaceae alopecuretosum bulbosi*, whose differential species are *Alopecurus bulbosus* subsp. *bulbosus*, *A. rendlei*, *Oenanthe fistulosa*, *Trifolium resupinatum*, *Centaurea jacea* subsp. *jacea*, *Galium debile*, and *Plantago lanceolata*.

In small depressions of few centimeters or in contact with marsh vegetation of the *Magnocaricion gracilis*, where water stands for more time during the year, *Carex acuta* tends to become codominant with *Phalaris arundinacea*. We attributed this aspect to a *Carex acuta* variant of the subassociation *Phalaridetum arundinaceae alopecuretosum bulbosi*.

CAREX OTRUBAE community (group 19, Suppl. material 1: Table S19, rels 1–5)

Species-poor plant community of the stagnant waters dominated by *Carex otrubae*, present exclusively along the banks of ditches of modest depth, which during the year undergo periods of submergence (winter-early spring) and emergence (summer), depending on the variability of the water supply resulting from rainfall.

Carex otrubae communities found by Venanzoni and Gigante (2000) at Lakes Trasimeno and Alviano (Umbria), Minissale and Spampinato (1995) and Brullo et al. (2002) in Sicily, by Cortini Pedrotti et al. (1973) and Pedrotti (1982a) at the Pian Grande of Castelluccio di Norcia (Umbria), attributed to *Cypero longi-Caricetum otrubae* or *Caricetum otrubae*, were placed in the *Magnocaricion elatae* alliance, while Buchwald (1994) placed the *Carex otrubae* coenoses found at Pian Grande and Pian Piccolo (Sibillini Mountains, Umbria) in the *Potentillion anserinae* alliance; instead, Lastrucci et al. (2014) attributed the *C. otrubae* community found at Lake Montepulciano to the *Cypero longi-Caricetum otrubae* association, in the *Mentho-Juncion inflexi*. Because of the absence of species of *Magnocaricion elatae*, and the prevalence of floristic entities of *Potentillion anserinae* and higher syntaxa (*Ranunculus repens*, *Gratiola officinalis*, *Carex hirta*, and *Galium album* subsp. *album*), we considered it more appropriate to place this plant community in the *Potentillion anserinae* alliance.

The *Carex otrubae* community is in contact, toward the center of the ditch section, with the *Oenantho aquaticae-Rorippetum amphibiae*, *Carici otrubae-Juncetum inflexi*, *Glycerietum notatae*, and *Caricetum vesicariae* associations, while toward the external areas, it is in contact with the humid meadows of the *Ranunculion velutini*.

GRATIOLA OFFICINALIS community (group 19, Suppl. material 1: Table S19, rels 6-11)

Community characterized by *Gratiola officinalis*, which colonizes soils undergoing alternation of spring floods and summer desiccation, with species from peaty and marshy meadows, such as *Carex panicea*, *Dactylorhiza incarnata*, *Ranunculus flammula*, and *Oenanthe fistulosa*, and elements of *Potentillo-Polygonetalia*, such as *Mentha pulegium* subsp. *pulegium*, *Carex hirta*, *C. otrubae*, *Ranunculus repens*, and *Galium album* subsp. *album*.

We found this community inside depressions 20-30 cm deep, surrounded by the humid meadows of *Ranunculion velutini* alliance.

Two associations physiognomically characterized by *Gratiola officinalis* have been identified in Hungary (*Ranunculo flammulae-Gratioletum* Borhidi and Juhász 1985 of the *Eleocharition acicularis* alliance, see Borhidi and Juhász 1985), the Czech Republic and Slovakia (*Lathyro palustris-Gratioletum* Balátová-Tuláčková 1966 of the *Deschampsion cespitosae* alliance, Botta-Dukát et al. 2005). In Italy, Pedrotti (1982b) referred the occurrence of a community characterized by *Gratiola officinalis*, *Juncus inflexus*, and *Mentha pulegium* in 20-40 cm deep depressions in the basin of Lake Trasimeno, however without phytosociological relevés. Biondi and Bagella (2005) described the *Alismo lanceolatae-Gratioletum officinalis* association (*Glycerio-Sparganion*) in Sardinia, and the same association was found by Gigante et al. (2013) on the western side of Lake Trasimeno (Umbria). Lastrucci and Becattini (2008) found in temporarily flooded meadows near "Bosco ai Frati" (Tuscany) a *Gratiola officinalis* community, attributed to the *Molinio-Arrhenatheretea* class.

Because of the different floristic composition and biogeographic contexts, the abovementioned syntaxa do not seem suitable for interpreting the analyzed community; however, there are no elements to describe a new association. Given the high frequencies of species of *Potentillion anserinae* and the higher syntaxonomic units, we propose placing this community in the *Potentillion anserinae* alliance.

OENANTHO AQUATICAE-RORIPPETUM AMPHIBIAE Lohmeyer 1950 (group 19, Suppl. material 1: Table S19, rel. 12-15)

Plant community physiognomically characterized by *Rorippa amphibia*, with *Mentha aquatica* subsp. *aquatica*, *Myosotis scorpioides* and other species of the *Phragmito-Magnocaricetea* class, such as *Phalaris arundinacea*, *Glyceria maxima*, *Alisma plantago-aquatica*, *Glyceria notata*, and *Typha latifolia*. Sometimes there are submerged hydrophytic rooting species, such as *Myriophyllum verticillatum*, *Ranunculus trichophyllus*, and *Callitriche stagnalis*. The occurrence of species such as *Gratiola officinalis*, *Ranunculus repens* and *Rumex conglomeratus* indicates an early dynamic stage of this community, which will probably lead to progressive terrestrialization, testified by the *Rorippa amphibia* community, extremely species-poor and mainly composed of nitrophilous and ruderal species, found at the border of the Palude di Colfiorito by Pedrotti and Murrja (2020).

We refer this community to the *Oenantho-Rorippetum* association and the *Eleocharito palustris-Sagittarion sagittifoliae* alliance, often published under the synonym name *Oenanthion aquaticae* Hejny 1948 (Baldoni and Biondi 1993; Biondi et al. 2003).

The plant community develops in stagnant or slowly flowing waters, less than 50 cm deep, in contact with communities of the *Phragmition communis* alliance. It is indicated in northern and central Italy (e.g. Pedrotti 1977; Baldoni and Biondi 1993; Marchiori et al. 1993; Biondi and Baldoni 1994; Marchiori and Sburlino 1997; Lastrucci et al. 2007; Pedrotti and Murrja 2020).

Changes in the occurrence of plant communities

In the relevés carried out in the period 1963-1977, Pedrotti reported 40 plant communities (Suppl. material 2: Table S20), 10 hydrophytic (*Charetea*, *Potamogetonetea*, and *Lemnetea* classes), 17 helophytic (*Phragmito-Magnocaricetea*), six humid meadow communities (*Molinio-Arrhenatheretea*), three communities of peat bogs (*Scheuchzerio-Caricetea nigrae*), two of temporarily flooded lands (*Bidentetea*), one of *Isoëto-Nanojuncetea*, and one of *Epilobietea angustifolii* (Pedrotti 1975, 2019) (Suppl. material 2: Table S20).

In our survey (years 2005-2009), we found 39 plant communities referred to the *Potamogetonetea* (six com-

munities), *Bidentetea* (2), *Phragmito-Magnocaricetea* (21), *Molinio-Arrhenatheretea* (9), and *Epilobietea angustifolii* (1) classes. Twenty-two of them confirm the findings of Pedrotti (1975, 1976, 2019), Buchwald (1994), Orsomando (2000, 2002), and Tardella et al. (2002), while 17 were new records for the study area. Twenty-four communities, found by Pedrotti (1975, 2019), instead, were not confirmed (eight of *Charetea*, *Lemnetea minoris*, and *Potamogetonetea*, one of *Bidentetea*; seven of *Phragmito-Magnocaricetea*; three of *Scheuchzerio-Caricetea fuscae*, four of *Molinio-Arrhenatheretea* and one of *Isoëto-Nanojuncetea*).

Changes in the occurrence of the habitats of conservation interest

As far as habitats of community interest are concerned, 19 plant communities found by Pedrotti in the 1960s/1970s can be ascribed to seven habitats of community interest (Suppl. material 2: Table S20). Three of these habitats (3140 – Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.; 3170* – Mediterranean temporary ponds; and 7230 – Alkaline fens) have not been confirmed in our research. In particular, habitat 7230, related to the peat bog, has completely disappeared. In the early 2000s, there was still a residual area characterized by *Carex panicea*, *Epipactis palustris*, and *Dactylorhiza incarnata* (Tardella, pers. obs.), which was invaded by *Phragmites australis* in the subsequent years (see Suppl. material 1: Table S10, relevés 6–7) and, then, by shrubs (Pedrotti 2019). The habitats that can be confirmed, also in the light of the most recent available relevés are: 3150 – Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation (two communities of the *Potamogetonion* and two of the *Nymphaeion* alliances); 3260 – Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (two communities of the *Ranunculion aquatilis*); 3270 – Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation (one community of the *Bidention tripartitae* and one of the *Chenopodion rubri*); and 6510 – Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) (two communities of the *Ranunculion velutini*).

Conclusions

We found a considerable richness in plant communities (39 vegetation units, belonging to five vegetation classes). Most of them are of high conservation interest in central Italy because they are endemic to the central and southern Apennines (meadows of the *Ranunculion velutini* alliance), rare or endangered in peninsular Italy (hydrophytic and helophytic vegetation of *Potamogetonetea* and *Phragmito-Magnocaricetea* classes), and deemed habitats of community interest according to the 92/43/EEC Directive. However, we did not confirm 24 plant communities found in the past, most of which can be attributed to habitats of community interest.

The studied wetland system underwent several alterations over time and is still threatened by the reduction of precipitation due to climate change, anthropic activities outside or bordering on the basins, such as tillage of croplands, circulation of agricultural vehicles, cropland fertilization that causes eutrophication of the water bodies, and unauthorized water collection for irrigation purposes. The lack or the discontinuity of management and maintenance interventions in part of the study area, especially the lack of management of the reed beds, canals, and ditches, could further negatively impact the biodiversity of the wetland system. The reed expansion to the outside of the basins, the increase in the extent of the *Nymphaeetum albae*, and the filling of small artificial watercourses is threatening rare species (e.g. *Ranunculus ophioglossifolius*, *R. flammula*, *Equisetum fluviatile*, and *Ophioglossum vulgatum*, see Ballelli et al. 2010) and fragmenting or substituting plant communities of small extent, such as some hydrophytic and therophytic communities. Moreover, these pressures are exacerbated by the absence of buffer zones covered by meadows between arable lands and wetlands.

To preserve plant species and vegetation diversity of these wetlands, besides the implementation of the usual maintenance activities (cleaning of ditches and mowing of the hay meadows), some conservation actions are advisable, such as the periodical mowing of the reed bed to contain its expansion outwards, and the removal of dead material from the bottom of water pools and canals. Finally, the monitoring of the species composition of plant communities, and of changes in the vegetation mosaic, periodically updating the vegetation maps, is of great importance for the management of the wetland system.

Syntaxonomic scheme

POTAMOGETONETEA Klika in Klika et Novák 1941
POTAMOGETONETALIA Koch 1926
Potamogetonion Libbert 1931
Potamogetono pectinati-Myriophylletum spicati Rivas Goday 1964
Myriophylletum verticillati Gaudet ex Šumberová in Chytrý 2011
Nymphaeion albae Oberd. 1957
Nymphaeetum albae Vollmar 1947
Persicaria amphibia community
Ranunculion aquatilis Passarge ex Theurillat in Theurillat et al. 2015
Potamogetono crispi-Ranunculetum trichophylli Imchenetzky 1926
Callitriche stagnalis community

BIDENTETEA Tüxen et al. ex von Rochow 1951
BIDENTETALIA Br.-Bl. et Tüxen ex Klika et Hadač 1944
Bidention tripartitae Nordhagen ex Klika et Hadač 1944

Bidentetum tripartitae Miljan 1933
Chenopodion rubri (Tüxen in Poli et J. Tüxen 1960) Hilbig et Jage 1972
Polygono lapathifolii-Xanthietum italici Pirola et Rossetti 1974

PHRAGMITO-MAGNOCARICETEA Klika in Klika et Novák 1941
PHRAGMITETALIA Koch 1926
Phragmition communis Koch 1926
Glycerietum maximae Nowiński 1930 corr. Šumberová, Chytrý et Danihelka in Chytrý 2011
Iridetum pseudacori Eggler 1933 ex Brzeg et M. Wojterska 2001
Phalaridetum arundinaceae Libbert 1931
typicum
alopecuretosum bulbosi subass. nova
alopecuretosum bulbosi subass. nova *Carex acuta* variant
Phragmitetum australis Savič 1926
Cyperetum longi (Micevski 1957) Micevski 1963
Schoenoplectetum lacustris Chouard 1924
Typhetum latifoliae Nowiński 1930
MAGNOCARICETALIA Pignatti 1953
Magnocaricion gracilis Géhu 1961
Caricetum gracilis Savič 1926
Caricetum ripariae Máthé et Kovács 1959
Caricetum vesicariae Chouard 1924
OENANTHETALIA AQUATICAE Hejný ex Bálatová-Tuláčková, Mucina, Ellmauer et Wallnöfer in Grabherr et Mucina 1993
Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964
Eleocharitetum palustris Savič 1926
Oenantho aquaticae-Rorippetum amphibiae Lohmeyer 1950
NASTURTIO-GLYCERIETALIA Pignatti 1953
Glycerio-Sparganion Br.-Bl. et Sissingh in Boer 1942
Beruletum erectae Roll 1938
Glycerietum notatae Kulczyński 1928
Rorippo ancipitis-Catabrosetum aquaticae (Oberdorfer 1957) Müller et Görs 1961
Helosciadietum nodiflori Maire 1924
Nasturtietum officinalis Gilli 1971
Sparganietum erecti Roll 1938
Veronica anagallis-aquatica subsp. *anagallis-aquatica* community

MOLINIO-ARRHENATHERETEA Tüxen 1937
TRIFOLIO-HORDEETALIA Horvatić 1963
Ranunculion velutini Pedrotti 1978
Deschampsio-Caricetum distantis Pedrotti 1976
Hordeo-Ranunculetum velutini Pedrotti 1976
POTENTILLO-POLYGONETALIA AVICULARIS Tüxen 1947
Potentillion anserinae Tüxen 1947
Carex hirta community
Carex otrubae community
Galega officinalis community
Gratiola officinalis community
Epilobium hirsutum community
Potentilla reptans community
Mentho longifoliae-Juncion inflexi T. Müller et Görs ex de Foucault 2009
Carici otrubae-Juncetum inflexi Minissale et Spampinato 1985

EPILOBIETEA ANGUSTIFOLII Tüxen et Preising ex von Rochow 1951
ARCTIO LAPPAE-ARTEMISIETALIA VULGARIS Dengler 2002
Balloto-Conion maculati S. Brullo et Marcenò 1985
Urtico dioicae-Sambucetum ebuli (Br.-Bl. in Br.-Bl., Gajewski, Wraber et Wa1as 1936) Br.-Bl. in Br.-Bl., Roussine et Nègre 1952

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Appendixes

Appendix I – Coordinates of localities.

Palude di Colfiorito: 43° 01.35' N; 12° 52.50' E
Piano di Annifo: 43° 02.50' N; 12° 52.20' E
Piano di Arvello: 43° 02.15' N; 12° 51.20' E
Piano di Colfiorito: 43° 02.30' N; 12° 54.60' E
Piano di Colle Croce: 43° 03.70' N; 12° 51.95' E
Piano di Popola e Cesi: 43° 00.00' N; 12° 53.85' E
Piano di Ricciano: 43° 00.45' N; 12° 50.90' E

Appendix II – Dates of relevés.

Suppl. material 1: Table S1 – Rels 1–10: 12/08/2006.

Suppl. material 1: Table S2 – Rels 1–4: 20/05/2006; rels 5–6: 27/05/2006; rels 7–8: 18/05/2009.

Suppl. material 1: Table S3 – Rels 1, 3, 6–9: 27/05/2006; rels 2: 18/05/2009; rels 4–5: 17/05/2008.

Suppl. material 1: Table S4 – Rels 1–3: 18/05/2009; rel. 4: 24/05/2008; rels 5–6: 26/08/2006; rels 7–8: 20/05/2006; rels 9: 30/05/2009; rel. 10: 03/09/2005; rels 11: 20/05/2006; rel. 12: 30/05/2009; rels 13–16: 20/05/2006.

Suppl. material 1: Table S5 – Rel. 1: 20/05/2006; rels 2: 27/05/2006; rels 3–4: 02/06/2005.

Suppl. material 1: Table S6 – Rels 1–2, 3, 9, 16, 19–20: 27/05/2006; rels 4, 5: 20/05/2006; rels 6–7, 27: 11/07/2005; rels 8, 18, 28: 03/09/2005; rels 10–15, 17, 29–30: 18/05/2009; rels 21: 27/05/2006; rels 22–23 02/06/2005; rels 24: 12/08/2006; rels 25–26: 21/06/2005.

Suppl. material 1: Table S7 – Rels 1–3: 27/05/2006.

Suppl. material 1: Table S8 – Rel. 1: 24/05/2008; rels 2, 8: 20/05/2006; rels 3–6, 9–11: 27/05/2006; rel. 7: 02/06/2005.

Suppl. material 1: Table S9 – Rels 1–2: 27/05/2006; rel. 3: 12/08/2006; rel. 4: 06/05/2006.

Suppl. material 1: Table S10 – Rels 1, 12–14: 27/05/2006; rels 2–3: 20/05/2006; Rel. 4–5: 26/08/2006; rels 6–7, 10–11, 15, 17–21: 03/09/2005; rels 8: 27/05/2006; rels 9, 11, 16: 18/05/2009.

Suppl. material 1: Table S11 – Rels 1–3, 5: 26/08/2006; rel. 4: 12/08/2006.

Suppl. material 1: Table S12 – Rels 1, 5: 26/08/2006; rels 2–3: 27/05/2006; rels 4, 7: 12/08/2006; rel. 6: 11/07/2005.

Suppl. material 1: Table S13 – Rel. 1: 24/05/2008;Rel. 2–3, 5: 10/06/2006; Rel. 4: 13/05/2006; Rel. 6–7, 7: 27/05/2006.

Suppl. material 1: Table S14 – Rels 1, 29–30, 34–37: 27/05/2006; rels 2–5: 24/06/2006; rels 6, 14–15: 24/05/2008; rels 7–8: 27/05/2006; rels 9–10: 20/05/2006;

rels 11, 16–17, 31, 33: 10/06/2006; rels 12–13, 20, 26: 18/05/2009; rels 21, 32: 02/06/2005; rels 22–23: 13/05/2006; rels 24–25: 20/05/2006; rels 27–28: 17/05/2008; rels 18–19: 31/05/2009.

Suppl. material 1: Table S15 – Rels 1–4: 11/07/2005.

Suppl. material 1: Table S16 – Rels 1, 6–7: 10/06/2006; rels 2: 10/06/2006; rels 3, 5, 11: 27/05/2006; rels 4, 12: 20/05/2006; rels 8–10: 02/06/2005; rels 13: 02/07/2005; rels14–15: 13/05/2006.

Suppl. materiale 1: Table S17 – Rel. 1: 27/05/2006; rel. 2: 10/06/2006.

Suppl. material 1: Table S18 – Rels 1–2: 20/05/2006; rels 3, 7–9, 19, 26–28: 27/05/2006; rels 4–5: 10/06/2006; rel. 6: 03/09/2005; rels 10, 18: 27/05/2006; rels 11–15: 11/07/2005; rels 16, 20–24, 31: 10/06/2006; rel. 25: 10/06/2006; rels 17, 29: 21/05/2005; rel. 30: 06/05/2006.

Suppl. material 1: Table S19 – Rels 1–5, 8–14: 27/05/2006; rel. 6: 13/05/2006; rel. 7: 13/05/2007; rel. 15: 24/05/2008.

Supplementary material 1

Tables S1–S19

Authors: Federico Maria Tardella, Vincenzo Maria Di Agostino

Data type: phytosociological tables

Explanation note: Phytosociological tables (Tables S1–S19) of the surveyed plant communities.

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Supplementary material 2

Table S20

Authors: Federico Maria Tardella, Vincenzo Maria Di Agostino

Data type: data table

Explanation note: List of the plant communities found in the current research and of those found by other authors in the past.

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